Report No. 80-9

AN INTERACTIVE PROGRAM FOR THE DOUGLAS-FIR TUSSOCK MOTH STAND OUTBREAK MODEL

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November 1980

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ABSTRACT

An interactive program has been installed at the Fort Collins Computer Center (FCCC) to assist users to create data files required for the Douglas-fir Tussock Moth Stand Outbreak Model programs. Instructions on how to use this interactive program are provided via examples in this report.

INTRODUCTION

Through a cooperative effort between Pacific Northwest Forest and Range Experiment Station and FPM/Methods Application Group, a report entitled "Data Preparation and Computer Runstream Procedures for the Douglas-fir Tussock Moth Stand Outbreak Model" was distributed (Colbert and Wong 1979). It was prepared under the premise that a comprehensive reference document should be assembled to serve as a single source of information on data input and output structure and computer access procedures for this model. The stand outbreak model is a component of the Douglas-fir Tussock Moth (DFTM) Pest Management System (Campbell and McFadden) developed under the USDA Expanded DFTM Research and Development Program (Wright 1977). This model has a generalized system structure. When new information becomes available it can be readily updated.

The basic documentation on the DFTM Stand Outbreak Model described data input and output structure for a variety of available options. However, the need exists to further simplify the data preparation procedures so that users with a minimal amount of training can readily create data files required to make simulations. To satisfy this need, an interactive program has been developed and placed on line at FCCC. Designed strictly for demand processing, this program can be accessed by an authorized FCCC user from a remote terminal.

In this report, it is assumed that the reader has already reviewed the aforementioned documentation for the DFTM Stand Outbreak Model (Colbert and Wong 1979). The reader should therefore be knowledgeable about the input

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files required and the information needed to make up these files. Primary intent of this report is to demonstrate how this new program can be utilized.

SYSTEMS OVERVIEW

The interactive program is conversational in nature and is capable of performing the following tasks:

1. Create the initial condition file (*IC.) and the parameters file (*PARAMETERS.) simultaneously (option 1) as input files for a simulation.

2. Create the specifications file (*SPECTAB4.) to retrieve detail information from a previous simulation (option 2).

3. Compute instar specific daily larval, pupal or overwintering mortality resulting from direct control as input to the generation of the parameters file (option 3).

This program is written in ASCII Fortran for the UNIVAC 1100 computer at FCCC. It resides in a program file named DFTM*UTILITY1.

PROGRAM FEATURES

Several special features have been built into the interactive program which will transform field data into a form readily acceptable by the model programs. Some of these special features are:

1. Capability to Enter Model at Any Stage of the Outbreak.

The DFTM Stand Outbreak Model was structured in a form such that the insect density (larval count) and the actual foliage conditions must be specified at the initiation (1st instar) of a phase. This requirement is not practical from the standpoint that insect densities at the 1st instar are not always available except under an established monitoring system when field activities are planned in advance. Recognizing this situation, the capability to "back-up" insect count available at some intermediate point, e.g. at the third day of the second instar, to the beginning of the first instar, has been incorporated into this program. To accomplish this task, the following functional form for insect survivorship is utilized:

$$N = N_0 \prod_{i=1}^{k} \prod_{j=1}^{\ell} (1 - p_{ij})^{d_{ij}}$$

where N = insect density at the initiation of a specific phase.

N_0 = instar density at the time of data collection.

i = the type of mortality associated with instar i.

P_{ij} = the mortality (value) associated with i and j.

d_{ij} = the time in days to be included for each instar.

2. Ability to Adjust Mortality Factors and Foliage Biomass Values.

A set of natural mortalities are stored within the program in the *PARAMETERS. file. Users can utilize these standard mortalities or make alterations when executing this program if other values are to be used. Foliage conditions--actual new foliage biomass and actual old foliage biomass in addition to nominal percent new foliage and nominal total foliage biomass--at the first instar of a specific phase must be available for a simulation to start from other than phase 1. For the phase 1 start, the actual foliage complements will be automatically computed from the nominal foliage values supplied by the user.

3. Ability to Create an Input File to Retrieve Detailed Information.

Option 2 provides the mechanism to set up the SPECTAB4. file to retrieve model details for up to six state or output variables; namely, new foliage biomass, old foliage biomass, number of insects, mean larval biomass, number of days on old foliage, and number of days without food. By entering the appropriate pair of indices sequentially, as shown in Fig. 8 of the basic considerations, the desired output can be obtained by executing DFTM*RUNSTREAM.TABLE4B.

4. Control Mortality Computation.

Another special feature is found in option 3, which is the control mortality algorithm. With this option, the user can obtain a value for the required control mortality factor to be entered into *PARAMETERS, when option 1 is processed. Using the same functional form as in the above formula, the daily control mortality or overwintering and pupal control mortality, as applicable, can be easily calculated. For the daily control rate, it is assumed that the initial and final insect densities are known at the beginning and end of instar. It is then computed as a function of these values, and all other mortalities entered. Furthermore, if stress mortality is to be considered, in computing daily control mortality, the user is expected to supply the number of days for which stress will operate[3]. In order to obtain an estimate of the number of days for which stress will operate a preliminary simulation will have to be made

3 Number of days stress operates is the number of days on old foliage.

with a phase 1 start, with insect densities ranging from 1-20 larvae/1000 square inch of foliage, and with nominal foliage conditions that best approximate the situations at hand. After this simulation is made, the information on the number of days on old foliage can be retrieved as discussed above.

EXAMPLES

The following synopsis was developed to show an example of how the Douglas-fir Tussock Moth Stand Outbreak Model with its new interactive front-end program could be used to make a pest management decision.

A combination of pheromone trapping and larval sampling indicates that a major up-surge of Douglas-fir tussock moth is about to occur in portions of eastern Oregon during late 1983. The infested area encompasses approximately 150,000 acres of predominately grand fir type. The outbreak is assumed to be entering Phase II in 1984. In October 1983, a decision must be made whether or not to begin plans for a direct control project.

Data from biological evaluations identifies five areas of infestation. Projected average 1st instar population trends in these areas at the beginning of Phase II are as follows:

Infestation Area	Projected 1st Instar Larvae (insects per 1,000 sq. in. of foliage)
1	50
2	75
3	110
4	150
5	200

At the time of this initial evaluation, no data are available on incidence of naturally occuring virus in the population of egg parasite levels or porportion of nonviable eggs. According to existing data, the proportion of nominal new foliage for grand fir in eastern Oregon is 30 percent and nominal foliage biomass on a mid-crown branch is 230 grams/1000 sq. in. The actual amount of new and old foliage at the beginning of Phase II is estimated to be 69 grams and 161 grams, respectively.

One alternative under consideration is direct control of the infestation with an aerial application of Sevin 4-Oil at 2 lbs to 3/4 gal. carrier per acre. Data from a 1974 pilot control project in northern Idaho (Ciesla et al. 1976) is used to compute daily mortality rates; and the Stand Outbreak Model is run with or without introduction on direct control to project population trends and impact. Data from this pilot control project were collected under the following conditions:

1. Phase of outbreak is Phase III.

2. Instar to which spray was applied was primarily the 3rd instar.

3. Prespray population density was 50.71 insects per 1,000 sq. in. of foliage.

4. Seven-day post-spray population density = 5.58 insects per 1,000 in. of foliage.

5. Fourteen day post-spray population density = .96 insects per 1,000 in. of foliage.

To use the Stand Outbreak Model for pest management decisionmaking, compute a daily control mortality rate from the 1974 data; enter that rate into the parameter file; and run simulations with and without a direct control mortality factor with a Phase II start; and then compare the population trends and impact.

The first step is to create *IC. and *PARAMETERS. files for the no control option as follows:

Runstream No. 1

Using these input files, make a simulation without control as follows:

```
>@RUN MØ1MAG,11Ø52Ø34050  ,WONG
DATE: Ø8Ø68Ø  TIME: 114337
S2K INFO - , S2ØØØ,8Ø=ØØØØ6  (@INFO)MONDAY 11:35
<@XQT DFTM*UTILITY1.

DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
  VERSION Ø1.ØØ1   COMPILED 6/3/8Ø


PROGRAM OPTIONS:  1= IC AND PARAMETERS FILE GENERATION
                  2= SPECTAB4 FILE GENERATION,
                  3= CONTROL MORTALITY   ALGORITHM
ENTER OPTION DESIRED
>1
*IC. FILE AND *PARAMETER. FILE GENERATION
ENTER RUN QUALIFIER
>WC1
RUN QUALIFIER  IS NOW WC1
ENTER NUMBER OF DOUGLAS FIR TREE CLASSES
>Ø
ENTER NUMBER OF GRAND FIR TREE CLASSES
>5
ENTER STARTING PHASE NUMBER
>2

DO YOU WANT TO DEFINE SUBSETS?  (YES/NO)
>NO
DO YOU WISH TO CHANGE PARAMETERS FILE VALUES?(YES/NO)
>NO


INITIAL CONDITIONS FILE GENERATION
ENTER NUMBER OF DAYS STRESS OPERATES IN
FIRST INSTAR, SECOND INSTAR, THIRD INSTAR, FOURTH INSTAR
>Ø,Ø,Ø,Ø

TREE CLASS DEFINITIONS:
  YOU HAVE SPECIFIED ØØØ DOUGLAS FIR TREE CLASSES
  AND ØØ5 GRAND FIR TREE CLASSES.  FOR EACH CLASS
  YOU WILL NEED TO ENTER 1 LINE CONTAINING THE FOLLOWING     VALUES:
       1.  NOMINAL % NEW FOLIAGE
       2.  NOMINAL TOTAL FOLIAGE BIOMASS
       3.  # OF VIABLE EGGS PER BRANCH
       4.  INSTAR OF EGG COUNT
       5.  DAY IN INSTAR OF EGG COUNT
```

```
      6.  ACTUAL NEW FOLIAGE BIOMASS
      7.  ACTUAL OLD FOLIAGE BIOMASS
>3Ø,23Ø,5Ø,1,1,69,16Ø
>3Ø,23Ø,75,1,1,69,161
>3Ø,23Ø,11Ø,1,1,69,16Ø
>3Ø,23Ø,15Ø,1,1,69,161
>3Ø,23Ø,2ØØ,1,1,69,161
IF YOU WANT A LISTING OF THE ENTIRE *IC FILE, ENTER      -1,-1,Ø
IF YOU WANT TO SEE ONE LINE, ENTER  LINE#,Ø,Ø
IF YOU WANT TO CHANGE A VALUE, ENTER  LINE#,ITEM#,NEW VALUE
TO CONTINUE WITH PROGRAM, ENTER Ø,Ø,Ø
>1,7,161
LINE   1 ITEM 7=  161.ØØØ
>3,7,161
LINE   3 ITEM 7=  161.ØØØ
>-1,-1,Ø
 2   .ØØØØØ   .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ 5Ø.ØØØØØ  1
 2   .ØØØØØ   .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ 75.ØØØØØ  2
 2   .ØØØØØ   .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ11Ø.ØØØØØ  3
 2   .ØØØØØ   .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ15Ø.ØØØØØ  4
 2   .ØØØØØ   .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ2ØØ.ØØØØØ  5
>Ø,Ø,Ø
*IC. AND *PARAMETERS.  FILE PREPARATION FOR PHASE 2 START COMPLETED
****GOODBYE****
>@FIN [4]
```

---

4 Cost for this run was $1.34.

Using these input files, make a simulation without control as follows:

Runstream No. 2

```
>@RUN MØ1MAG, 11Ø52Ø34Ø5  , WONG
DATE: Ø8Ø68Ø   TIME: 115321
S2K INFO - , S2ØØØ,8Ø-ØØØØ6 (@INFO)MONDAY  11:35
>@QUAL WC1
READY
>@ADD,L  DFTM*RUNSTREAM.PRE2


@DELETE,C *LUN25.
FURPUR 27R3A       E35  SL73R1  Ø8/Ø6/8Ø  11:54:34

*LUN25       IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *LUN25.
READY


*USE 25,*LUN25
READY


@DELETE,C *LUN1Ø.
FURPUR 27R3A         E35  SL73R1  Ø8/Ø6/8Ø  11:54:44

*LUN1Ø   IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *LUN1Ø.
READY


@USE  10,*LUN1Ø
READY


@ASG,T  *4
READY


@ASG,T  *5
READY


@ASG,T  *6
READY
```

```
@ASG,T  *7
READY


@ASG,T  *8
READY


@ASG,T  *9
READY


@ASG,T  *11
READY


@ASG,T  *12
READY


@DELETE,C  *15.
FURPUR 27R3A          E35  SL73R1  Ø8/Ø6/8Ø  11:55:34

*15       IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *15
READY


@FREE  *15.
READY


@ASG,A  *15.
READY


@DELETE,C  *16.
FURPUR 27R3A          E35  SL73R1  Ø8/Ø6/8Ø  11:56:06

*16       IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *16
READY


@FREE  *16.
READY
```

```
*ASG,A  *16.
READY


*DELETE,C  *17
FURPUR 27R3A       E35  SL73R1  Ø8/Ø6/8Ø  11:56:28


*17       IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *17
READY


@FREE  *17.
READY


@ASG,A  *17.
READY


@ASG,T  *18
READY


@ASG,T  *19
READY


@ASG,T  *2Ø
READY


@DELETE,C  *21.
FURPUR 27R3A         E35  SL73R1  Ø8/Ø6/8Ø  11:56:52

*21       IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØ1ØØØØØØØ


@ASG,UP  *21
READY


@FREE  *21.
READY


@ASG,A  *21.
READY
```

```
@ASG,T  *22
READY


@ASG,T  *23
READY


@ASG,T  *24
READY


@ASG,A  DFTM*DFTMDF.
FACILITY WARNING  ØØØ2ØØØØØØØØ


@USE  13,DFTM*DFTMDF
READY


@ASG,A  DFTM*DFTMGF.
FACILITY WARNING  ØØØ2ØØØØØØØØ


@USE  14,DFTM*DFTMGF
READY


@ASG,A  *IC.
READY


@ASG,A  *PARAMETERS.
READY


@USE  3Ø,*IC
READY


@USE  6Ø,*PARAMETERS
READY
>@XQT DFTM*OUTBREAK.
>@ADD,L DFTM*RUNSTREAM.POST2


@FREE  *2
FACILITY WARNING  1ØØØØØØØØØØØ


@FREE  *3
FACILITY WARNING  1ØØØØØØØØØØØ
```

```
@FREE  *4
READY

@FREE  *5
READY

@FREE  *6
READY

@FREE  *7
READY

@FREE  *8
READY

@FREE  *9
READY

@FREE  *1Ø
READY

@FREE  *11
READY

@FREE  *12
READY

@FREE  *13
READY

@FREE  *14
READY

@FREE  *18
READY

@FREE  *19
READY

@FREE  *2Ø
READY
```

```
@FREE  *21
READY


@FREE  *22
READY


@FREE  *23
READY


@FREE  *24
READY


@FREE  *25
READY
>@SYM,U  *15.,,FCR1Ø4
>@SYM,U  *16.,,FCR1Ø4
>@SYM,U  *17.,,FCR1Ø4
>@FIN
```
[5]

---

5 Cost for this run was $3.37.

Then compute a direct control daily mortality rate. The runstream appears as follows:

Runstream No. 3

```
UNS>@RUN  MØ1MAG,11Ø52Ø34Ø5  WONG
DATE:  Ø8Ø68Ø  TIME:  113813
S2K INFO -, S2ØØØ,8Ø-ØØØØ6 (@INFO)MONDAY 11:35
>@XQT DFTM*UTILITY1.

DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
  VERSION Ø1.ØØ1   COMPILED 6/3/8Ø


PROGRAM OPTIONS:  1= IC AND PARAMETERS FILE GENERATION
                  2= SPECTAB4 FILE GENERATION,
                  3= CONTROL MORTALITY   ALGORITHM
ENTER OPTION DESIRED
>3
CONTROL MORTALITY ALGORITHM

ENTER OPTION CODE
    DAY=DAILY CONTROL MORTALITY
    PUP=PUPAL CONTROL MORTALITY
    OVW=OVERWINTER CONTROL MORTALITY
    TER=TERMINATE PROGRAM
>DAY
ENTER PHASE
>3
ENTER INSTAR
>3
ENTER TREE TYPE(DF=DOUGLAS FIR,GF=GRAND FIR)
>GF
NATURAL DAILY MORTALITIES:
PREDATOR/PARASITE= .ØØ3 DISEASE= .ØØ6 BACK GROUND= .Ø2Ø STRESS= .1ØØ
CHANGE ANY NATURAL MORTALITIES?(YES/NO)
>NO
ENTER NUMBER OF DAYS STRESS OPERATES
>Ø
ENTER BEGINNING INSECT COUNT
>5Ø.71
ENDING INSECT COUNT WITH NATURAL MORTALITY ONLY= 37.9
ENTER ENDING COUNT WITH CONTROL
>3.Ø[6]
DAILY CONTROL MORTALITY= .2239
ENTER OPTION
>TER
 ROUTINE TERMINATED
CONTROL MORTALITY ALGORITHM COMPLETED
****GOODBYE****
>@FIN[7]
```

---

6 This number was estimated from 1974 pilot project data.

7 Cost for this run was $0.37.

Next create the *IC. and *PARAMETERS. File for the direct control option as follows:

Runstream No. 4

```
>@RUN MØ1MAG,11Ø52Ø34Ø5  ,WONG
DUP ID, NEW ID IS MØ1MAH
DATE:  Ø8Ø68Ø  TIME: 12Ø321
S2K INFO - , S2ØØØ,8Ø-ØØØØ6 (@INFO)MONDAY 11:35
>@XQT DFTM*UTILITY1.


DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
  VERSION Ø1.ØØ1   COMPILED 6/3/8Ø


PROGRAM OPTIONS:  1= IC AND PARAMETERS FILE GENERATION
                  2= SPECTAB4 FILE GENERATION,
                  3= CONTROL MORTALITY    ALGORITHM
ENTER OPTION DESIRED
>1
*IC. FILE AND *PARAMETER. FILE GENERATION
ENTER RUN QUALIFIER
>WC2
RUN QUALIFIER IS NOT WC2
ENTER NUMBER OF DOUGLAS FIR TRE CLASSES
>Ø
ENTER NUMBER OF GRAND FIR TREE CLASSES
>5
ENTER STARTING PHASE NUMBER
>2

DO YOUT WANT TO DEFINE SUBSETS?  (YES/NO)
>NO

WHAT?
>NO
DO YOU WISH TO CHANGE PARAMETERS FILE VALUES?(YES/NO)
>YES
TO CHANGE A PARAMETERS FILE VALUE,ENTER A TRIPLE
(RECORD NUMBER,ITEM NUMBER,NEW VALUE)

TO OBTAIN THE LABEL AND CURRENT VALUE OF A PARTICULAR ITEM,ENTER
A TRIPLE    (-RECORD NUMBER,ITEM NUMBER,Ø)

TO PRINT THE ENTIRE PARAMETERS FILE ENTER THE TRIPLE -1,-1,Ø
```

```
WHEN YOU ARE DONE ENTERING VALUES,ENTER THE TRIPLE Ø,Ø,Ø
>14,1,2239
RECORD 14, ITEM 1
DAILY CONTROL MORTALITY RATE[8] FOR PHASE 2       INSTAR 1
HAS THE VALUE     .2239ØØØ
>Ø,Ø,Ø

INITIAL CONDITIONS FILE GENERATION
ENTER NUMBER OF DAYS STRESS OPERATES IN
FIRST INSTAR, SECOND INSTRAR, THIRD INSTAR, FOURTH INSTAR
>Ø,Ø,Ø,Ø

TREE CLASS DEFINITIONS:
  YOU HAVE SPECIFIED ØØØ DOUGLAS FIR TREE CLASSES
  AND ØØ5 GRAND FIR TREE CLASSES.  FOR EACH CLASS
  YOU WILL NEED TO ENTER 1 LINE CONTAINING THE FOLLOWING     VALUES:
       1.  NOMINAL % NEW FOLIAGE
       2.  NOMINAL TOTAL FOLIAGE BIOMASS
       3.  # OF VIABLE EGGS PER BRANCH
       4.  INSTAR OF EGG COUNT
       5.  DAY IN INSTAR OF EGG COUNT
       6.  ACTUAL NEW FOLIAGE BIOMASS
       7.  ACTUAL OLD FOLIAGE BIOMASS
>3Ø,23Ø,5Ø,1,1,69,161
>3Ø,23Ø,75,1,1,69,161
>3Ø,23Ø,11Ø,1,1,69,161
>3Ø,23Ø,15Ø,1,1,69,161
>3Ø, 23Ø,2ØØ,1,1,69,161
IF YOU WANT A LISTING OF THE ENTIRE *IC FILE, ENTER       -1,-1,Ø
IF YOU WANT TO SEE ONE LINE, ENTER LINE #,Ø,Ø
IF YOU WANT TO CHANGE A VALUE, ENTER LINE #,ITEM#,NEW VALUE
TO CONTINUE WITH PROGRAM, ENTER Ø,Ø,Ø
>-1,-1,Ø
  2  .ØØØØØ  .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ 5Ø.ØØØØØ  1
  2  .ØØØØØ  .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ 75.ØØØØØ  2
  2  .ØØØØØ  .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ11Ø.ØØØØØ  3
  2  .ØØØØØ  .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ15Ø.ØØØØØ  4
  2  .ØØØØØ  .ØØØØØ  3Ø.ØØØØØ23Ø.ØØØØØ  69.ØØØØØ161.ØØØØØ2ØØ.ØØØØØ  5
>Ø.Ø.Ø
*IC. AND *PARAMETER. FILE PREPARATION FOR PHASE 2 START COMPLETED
****GOODBYE****
>@FIN [9]
```

---

8 Direct control applied at Phase II, Instar 1.

9 Cost for this run was $1.30.

Finally, run a simulation with the control option as follows:

Runstream No. 5

```
>@RUN MØ1MAG,11Ø52Ø34Ø5  , CIESLA
DUP ID, NEW ID IS MØ1MAH
DATE:  18Ø68Ø   TIME: 121251
S2K INFO - , S2ØØØ,8Ø-ØØØØ6 (@INFO)MONDAY 11:35
>@QUAL WC2
READY
>@ADD,L  DFTM*RUNSTREAM.PRE2


@DELETE,C  *LUN25.
FURPUR 27R3A        E35 SL73R1  Ø8/Ø6/8Ø  12:14:04

LUN25    IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *LUN 25.
READY


@USE 25,*LUN25
READY


@DELETE,C  *LUN1Ø.
FURPUR 27R3A         E35 SL73R1  Ø8/Ø6/8Ø  12:14:17

@LUN1Ø   IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *LUN1Ø.
READY


@USE  10,LUN1Ø
READY


@ASG,T  *4
READY


@ASG,T  *5
READY
```

```
@ASG,T  *6
READY


@ASG,T  *7
READY


@ASG,T  *8
READY


@ASG,T  *9
READY


@ASG,T  *11
READY


@ASG,T  *12
READY


@DELETE,C  *15.
FURPUR 27R3A         E35 SL73R1  Ø8/Ø6/8Ø  12:14:48

*15       IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ

@ASG,UP  *15
READY


@FREE  *15.
READY


@ASG,A  *15.
READY


@DELETE,C  *16.
FURPUR 27R3A         E35 SL73R1  Ø8/Ø6/8Ø  12:15:15

*16       IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *16
READY
```

```
@FREE  *16.
READY


@ASG,A  *16.
READY


@DELETE,C  *17.
FURPUR 27R3A         E35  SL73R1  Ø8/Ø6/8Ø  12:15:37

* 17     IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,UP  *17
READY


@FREE  *17.
READY


@ASG,A  *17.
READY


@ASG,T  *18
READY


@ASG,T  *19
READY


@ASG,T  *2Ø
READY


@DELETE,C  *21.
FURPUR 27R3A         E35  SL73R1  Ø8/Ø6/8Ø  12:15:58

*21      IS NOT CATALOGUED OR ASSIGNED
FAC STATUS:  4ØØØ1ØØØØØØØ


@ASG,UP  *21
READY


@FREE  *21.
READY
```

```
@ASG,A  *21.
READY


@ASG,T  *22
READY


@ASG,T  *23
READY


@ASG,T  *24
READY


@ASG,A DFTM*DFTMDF.
FACILITY WARNING ØØØ2ØØØØØØØØ


@USE 13,DFTM*DFTMDF
READY


@ASG,A DFTM*DFTMGF.
FACILITY WARNING ØØØ2ØØØØØØØØ

@USE 14,DFTM*DFTMGF
READY


@ASG,A  *IC.
READY


@ASG,A  *PARAMETERS
READY


@USE 3Ø,*IC
READY


@USE 6Ø,*PARAMETERS
READY
>@XQT DFTM*OUTBREAK.
>ADD,L DFTM*RUNSTREAM.POST 2
ADDX
DATA IGNORED - IN CONTROL MODE
>AD
@ADD,L DFTM*RUNSTREAM.POST2
```

```
@FREE *2
FACILITY WARNING 1ØØØØØØØØØØØ

@FREE *3
FACILITY WARNING 1ØØØØØØØØØØØ

@FREE *4
READY

@FREE *5
READY

@FREE *6
READY

@FREE *7
READY

@FREE *8
READY

@FREE *9
READY

@FREE *1Ø
READY

@FREE *11
READY

@FREE *12
READY

@FREE *13
READY

@FREE *14
READY

@FREE *18
READY
```

```
@FREE *19
READY


@FREE *2Ø
READY


@FREE *21
READY


@FREE *22
READY


@FREE *23
READY


@FREE *24
READY


@FREE *25
READY
>@SYM,U  *15.,,FCR1Ø4
>@SYM,U  *16.,,FCR1Ø4
>@SYM,U  *17.,,FCR1Ø4
>FIN [10]
```

---

10 Cost for this run was $3.46.

Model ouputs for control vs no control under these conditions are compared in tables 1-6 for each infested area. After these model simulations have been made, option 2 of the front-end program was used to create the specification file to make a post-simulation run. The runstream for creating the specification file follows:

Runstream No. 6

```
>@RUN MØ1MAG,11Ø52Ø34Ø5  ,WONG
DATE: Ø8/11/8Ø  TIME: 115751
>@ASG,A DFTM*UTILITY1.
READY
>@XQT DFTM*UTILITY1.

DFTM OUTBREAK MODEL DATA PREPARATION UTILITY
  VERSION Ø1.ØØ1    COMPILED 6/3/8Ø


PROGRAM OPTIONS:  1= IC AND PARAMETERS FILE GENERATION
                  2= SPECTAB4 FILE GENERATION.
                  3= CONTROL MORTALITY     ALGORITHM
ENTER OPTION DESIRED
>2
*SPECTAB4. FILE GENERATION
ENTER RUN QUALIFIER
>WC2
RUN QUALIFIER IS NOW WC2
ENTER NUMBER OF TREE CLASSES
>5
ENTER PAIRS OF NUMBERS(ONE PAIR PER LINE) FOR EACH ITEM DESIRED
FROM THE TABLE4. PROGRAM.
WHEN FINISHED ENTERING PAIRS,ENTER Ø,Ø
>1,3
>2.3
>3.3
>4.3
>5.3
>6.3
>7.3
>8.3
>9.3
>1Ø.3
>Ø,Ø
OPTION CODES:
      T=TERMINATE PROGRAM NORMALLY
      C=CHANGE AN ITEM IN *SPECTAB4. FILE
      A=ADD AN ITEM TO *SPECTAB4. FILE
      L=LIST CURRENT *SPECTAB4. FILE
      D=DELETE AN ITEM FROM *SPECTAB4. FILE
```

```
ENTER OPTION CODE
>T
***WC2*SPECTAB4 HAS BEEN GENERATED WITH 1Ø ITEMS***
*SPECTAB4.  FILE PREPARATION COMPLETED
****GOODBYE****
>@FIN[11]
```

---

11 Cost for the run was $0.87.

With this specification file, a computer run was made to retrieve information on the numerical changes of the population resulting from control. The runstream for the post-simulation run follows:

Runstream No. 7

```
>@RUN MØ1MAG,11Ø52Ø34Ø5   ,WONG
DATE: Ø8118Ø   TIME: 12Ø252
>@QUAL WC2
READY
>@ADD,L DFTM*RUNSTREAM,TABLE4B


@ASG,A *SPECTAB4
READY


@ASG,A *LUN1Ø.
READY


@ASG,A *LUN25.
READY


@DELETE,C *TABLE4.
FURPUR 27R3A         E35 SL73R1  Ø8/11/8Ø  12:Ø3:38

*TABLE4   IS NOT CATALOGUED OR ASSIGNED
FAC STATUS: 4ØØØ1ØØØØØØØ


@ASG,CP *TABLE4.
READY


@USE 11,*TABLE4
READY


@USE 12,*SPECTAB4
READY


@USE 1Ø,*LUN1Ø
READY


@USE 25,*LUN25
READY
```

```
@XQT DFTM*NTABLE4.A2
THERE WERE    5 TREE CLASSES COUNTED IN *LUN1Ø.
REQUEST IS TO PROCESS THE FIRST     5 TREE CLASSES
THERE WERE   1Ø VALID ITEMS REQUESTED


@FREE 11
READY


@FREE *TABLE4.
FACILITY WARNING  1ØØØØØØØØØØØ


@FREE 12
READY


@FREE 1Ø
READY


@FREE 25
READY
>@SYM,U *TABLE4.,2,FCR1Ø4
>@FIN [12]
```

---

12 Cost of this run was $0.53.

The output table from this run is shown in Table 7.

The user should find it very instructional to construct examples similar to those provided in this report. With a few practice sessions on the terminal, the operating characteristics of the front-end program can be grasped quickly, by a person with very little background in computers. When a large number of simulations have to be made, this program should prove to be a real time saving tool.

PROGRAM VARIABLE DEFINITIONS

In this Section, the definitions of the variables names used in the program source codes are explained in terms of their name, type, size, and usage. The source codes for this program can be made available upon request. It is anticipated that additional capabilities will be installed as the need arises. Revisions of this document will be made accordingly to provide the user with the latest information.

ICFILE (Subroutine):

NAME	TYPE	SIZE	USAGE
ITIC	I	200,9	matrix containing the integer values of the IC file
TIC	R	200,9	matrix containing the real values of the IC file NOTE: ITIC and TIC have been equivalenced and are therefore actually stored in the same memory locations. Use of ITIC and TIC allow both real and integer values to be stored in the same matrix
NDF	I		user-input number of Douglas-fir tree classes
NGF	I		user-input number of Grand fir tree classes
NTC	I		total number of tree classes (NDF + NGF)
NPHASE	I		user-input starting phase
IND	I		counter for number of tree classes processed so far. In this version also use as the tree class index (9th item in the current record of the IC file) & equal to K
TIC(K,8)	R		calculated insect density for Kth tree class. If TIC(K,8) is greater than 1000, message printed and program terminated

NAME	TYPE	SIZE	USAGE
ITIC(K,1)	I		species code (1 = Douglas-fir; 2 = Grand fir)
I1	I		user-input editing code for IC file. May be a line (or row, or record) number of an entry in the IC file or merely a code for printing or continuation of program
I2	I		user-input editing code for IC file. May be an item (or column) number of an entry in the IC file or merely a code for printing or continuation of program
VAL	R		user-input new value for the (I1,I2)th entry in the IC file or a code for printing or continuation of program
IVAL	I		integer form of VALUE for integer entries in the IC file
SDAY	I	6	Number of days stress operates in instars 1 to 6. SDAY (1) to SDAY (4) are user input; SDAY (5) and SDAY (6) are always zero.
K	I		Line (or record) number of current tree class in IC file

PRFILE (Subroutine):

NAME	TYPE	SIZE	USAGE
NTC	I		number of tree classes
NPHASE	I		starting phase
PRN	R	24.6	matrix containing records 2-25 of the PARAMETERS file
IPR1	I	22	vector containing first record of the PARAMETERS file
ANSW	C*3		character variable containing a user-input response (yes/no)
ICODE	I		numerical code corresponding to value of ANSW: "no" = -1, "yes" = +1, otherwise = 0
I	I		user-input number of tree class subsets before checking for allowable values
NPOSUB	I		maximum possible number of subsets given the number of tree classes (NTC)

NAME	TYPE	SIZE	USAGE
NSUBS	I		number of tree class subsets after checking for allowable values
I1	I		current user-input low subset index before checking for error. Becomes IPR1(J2 + 1) if no error
I2	I		current user-input high subset index before checking for error. Becomes IPR1(J2 + 2) if no error
VALUE	R		user-input new value for (I1, I2)th entry in the PARAMETERS file
J	I		subset currently being input is the Jth subset
J2	I		position of last accepted entry in IPR1 vector (=J*2 because entries 1 and 2 in IPR1 are always NPHASE & NTC, and because there are 2 entries per subset pair)

MAIN (Main Program):

NAME	TYPE	SIZE	USAGE
IPR1	I	22	vector containing the first record of the PARAMETERS file
PRN	R	24,6	matrix containing records 2-25 of the PARAMETERS file
IOPT	I		option code for desired subroutine

AMPLF (Subroutine):

NAME	TYPE	SIZE	USAGE
I	I		record (or row) number of item in PARAMETERS file
J	I		item (or column) number of item in PARAMETERS file
IPR1	I	22	vector containing first record of the PARAMETERS file
PRN	I	24,6	matrix containing records 2-25 of the PARAMETERS file
M	I		M = ABS(I)
N	I		N = ABS(J)
IR	I		IR = N module 2 (used in the program to determine whether an item number is odd or even)

NAME	TYPE	SIZE	USAGE
INDEX	I		number of tree class subset cooresponding to item (1,j) in the PARAMETERS file

SALUTE (Subroutine):

NAME	TYPE	SIZE	USAGE
IGEN	I		generation number (changed when recompiling program)
IVER	I		version number (changed when recompiling program)
CDATE	I	8	date of compilation (changed when recompiling)

SOLONG (Subroutine):

NAME	TYPE	SIZE	USAGE
IOPT	I		subroutine option code
NPHASE	I		starting phase

NCLASS (Subroutine):

NAME	TYPE	SIZE	USAGE
NCL	I		number of tree classes (input by user)
IL	I		lower bound to number of tree classes (fixed in program version)
IH	I		upper bound to number of tree classes (fixed in program version)

ABRTR (Subroutine):

NAME	TYPE	SIZE	USAGE
ISTAT	I		error status code returned after executive request initiated by routine FACSF

GETFLS (Subroutine):

NAME	TYPE	SIZE	USAGE
CCD	C*40		contains character string for the @QUAL executive request
QUAL	C*72		user-entered run qualifier including leading and trailing blanks
QUALIF	C*1	12	qualifier squeezed down to 12 characters (including trailing blanks, if any)

NAME	TYPE	SIZE	USAGE
QTEST	C*1		contains sequential characters from QUAL for testing (for blanks). Also used as user-input response code.
IDUPMS	O		octal error status code for: "another file already assigned with same number but different qualifer"
INOCAT	O		octal error status code for: "no cataloged file with name given in an @DELETE executive request"
ISTAT	I		error status returned after executive request initiated by FACSF routine
LQUAL	I		counter for number of characters in qualifier
ISTATR	I		same usage as ISTAT
QTEST	I		also used to contain a character-type user response
I	I		counter for number of characters in QUAL checked for blanks
TCLASS (Subroutine):			
NEND	I		counter for number of EOF's read - if greater than 2, run is terminated
NF	I		number of tree classes
TYPE	R		variable indicates record number of appropriate stress mortality (DF or GF) in PRN matrix-- = 18 for DF, = 19 for GF
IPR1	I	22	vector containing first record of PARAMETERS file
PRN	R	24,6	matrix containing records 2 through 25 of PARAMETERS file
NDFC	I		number of Douglas-fir tree classes
FIC	R	200,9	matrix containing entries for the IC file
INSTAR	I		instar of insect count
DAY	I		day within instar of insect count
FIC6	R		if NPHASE is greater than 1, 6th item in current record of FIC (actual new foliage biomass) is set = FIC6

NAME	TYPE	SIZE	USAGE
FIC7	R		if NPHASE is greater than 1, 7th item in current record of FIC (actual old foliage biomass) is set = FIC7
I	I		counter for number of times user has input a line of data
NPHASE	I		starting phase
D	R		total survivorship from beginning of phase to INSTAR, DAY
IENT	I		number of records read so far
ILEFT	I		number of records left to be read
NDAY	I	6	same usage as SDAY in ICFILE routine
INITID	L		not used in this version
CHANGE (Subroutine):			
I	I		indicates record (or row) number of entry in PARAMETERS file
J	I		indicates item (or column) number of entry in PARAMETERS file
VAL	R		new value for (I,J)th entry in PARAMETERS file
IVAL	I		new value for (1,j)th entry in PARAMETERS file
IPR1	I	22	vector containing first record of PARAMETERS file
PRN	R	24,6	matrix containing records 2-25 of PARAMETERS file
SPCT4 (Subroutine):			
IX1	I		user-input first member of pair before checking for error
IX2	I		user-input second member of pair before checking for error
I	I		counter for number of characters checked for blank in QUAL. Also counter for number of pairs entered in I1 & I2 vectors
KTOTAL	I		number of tree classes

NITEM	I		number of accepted items (pairs) in SPECTAB4
NUM	I		position number of pair for editing
ICK	I		loop index for checking new pair for duplication in existing pair list
CCD	C*40		contains the character string that makes up executive request "@QUAL (qualifier)"
QUAL	C*72		user-entered run qualifier including leading and trailing blanks
QTEST	C*1		contains successive single characters from QUAL for testing (for blank character). Also used as user-input response code.
QUALIF	C*1	12	qualifier squeezed down to 12 characters (including trailing blanks, if any)
I1	I	47	vector of 1st members of SPECTAB4 pairs
I2	I	47	vector of 2nd members of SPECTAB4 pairs
IDUPMS	O		octal error status code for: another file exists with same name but a different qualifier (usually following an @ASG executive request)
INOCAT	O		octal error status code for: no existing cataloged file with name given in an @DELELTE executive request
ISTAT	I		error status returned after executive request command initiated through FACSF routine
LQUAL	I		counter for number of characters in qualifier

ACKNOWLEDGEMENTS

We would like to thank William Ciesla, FIDM/MAG; Jed Dewey, R-1, FPM; and Paul Buffam, R-6, FPM for their review of this report. We also appreciate the cooperation of the staff at the Siuslaw National Forest, Supervisors Office, Corvallis, Oregon, in allowing us to use their computer facilities throughout this project.

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Table 1. First output table from simulation without control.

		PHASE I						PHASE II					
		INPUTS			OUTPUTS			INPUTS			OUTPUTS		
TREE CLASS NO.	NUMBER OF STEMS	VIABLE EGGS (NO.)	TOTAL FOLIAGE BIOMASS (GRAMS)	PERCENT NEW FOLIAGE (%)	DEFOLIA-TION (%)	VIABLE EGGS LAID (NO.)	REDIS-TRIBUTED EGGS (NO.)	VIABLE EGGS (NO.)	TOTAL FOLIAGE BIOMASS (GRAMS)	PERCENT NEW FOLIAGE (%)	DEFOLIA-TION (%)	VIABLE EGGS LAID (NO.)	REDIS-TRIBUTED EGGS (NO.)
1	.000	.000	.000	.000	.000	.000	.000	50.000	230.000	30.000	26.138	543.166	543.166
2	.000	.000	.000	.000	.000	.000	.000	75.000	230.000	30.000	43.814	708.832	708.832
3	.000	.000	.000	.000	.000	.000	.000	110.000	230.000	30.000	67.792	866.013	866.013
4	.000	.000	.000	.000	.000	.000	.000	150.000	230.000	30.000	88.232	931.993	931.993
5	.000	.000	.000	.000	.000	.000	.000	200.000	230.000	30.000	95.358	867.073	867.073
		PHASE III						PHASE IV					
1	.000	217.266	220.983	27.144	66.900	74.308	74.308	11.146	122.050	37.624	48.672	1.997	1.997
2	.000	283.533	183.113	29.427	87.851	67.430	67.430	10.115	66.633	58.066	72.605	1.812	1.812
3	.000	346.405	119.691	38.108	73.004	5.618	5.618	.843	105.905	41.371	54.086	.151	.151
4	.000	372.797	65.627	58.756	89.713	.525	.525	.079	61.710	61.658	73.182	.014	.014
5	.000	346.829	46.779	77.174	96.636	.489	.489	.073	43.397	82.173	81.143	.013	.013

Table 2. Second output table from simulation without control.

TREE CLASS NO	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS PHASE I	MODEL BRANCH: PERCENT DEFOLIATION BY PHASE				PERCENT OF TREE TOTALLY DEFOLIATED	PER CENT OF TREES RECEIVING:			
				I	II	III	IV		DIRECT MORTALITY	SECONDARY MORTALITY	TOP KILL	ONLY GROWTH REDUCTION
1	.0	0	.000	.000	26.138	66.900	48.672	12.035	.0	4.4	5.6	90.0
2	.0	.0	.000	.000	43.814	87.851	72.605	92.358	17.3	9.3	34.4	39.0
3	.0	.0	.000	.000	67.792	73.004	54.086	35.016	.9	4.5	27.0	67.6
4	.0	.0	.000	.000	88.232	89.713	73.182	94.279	17.3	9.3	34.4	39.0
5	.0	.0	.000	.000	95.358	96.636	81.143	97.343	47.7	7.8	21.5	23.0

TREE CLASS NO.	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS PHASE I	PER CENT OF TREES BY PERCENT REDUCTION IN CROWN HEIGHT					GROWTH IN SURVIVING TREES WITH NO TOP KILL PERCENT OF NOMINAL		DIAMETER GROWTH IN TREES WITH TOP KILL
				0.0	5.0	17.5	37.5	70.0	DIAMETER	HEIGHT	PERCENT OF NOMINAL
1	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
2	.0	.0	.00	19.3	5.9	2.2	1.6	5.4	69.10	69.10	69.10
3	.0	.0	.00	13.3	8.9	3.2	1.2	.4	74.00	74.00	74.00
4	.0	.0	.00	19.3	5.9	2.2	1.6	5.4	69.10	69.10	69.10
5	.0	.0	.00	9.6	4.0	2.7	.0	5.1	61.90	61.90	61.90

Table 3. Third output table from simulation without control.

DESCRIPTION	PHASE	SPECIES	INSTAR 1	2	3	4	5	6	OCCASION PUPAE/ADULT	OVERWINTER	EGG MASS SIZE
DAILY MORTALITY SOURCE			DAILY MORTALITY RATE						LIFE STAGE MORTALITY RATES		
BACKGROUND	I, II, III, IV	DF, GF	.020	.020	.020	.020	.020	.020			
DISEASE	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.002	.003	.006	.013	.035	.028			
	IV	DF, GF	.025	.028	.031	.034	.035	.035			
PARASITE/PREDATOR	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.001	.002	.003	.010	.016	.042			
	IV	DF, GF	.005	.006	.007	.021	.033	.056			
STRESS	I, II, III, IV	DF	.920	.600	.070	.000	.000	.000			
	I, II, III, IV	GF	.950	.700	.100	.020	.000	.000			
CONTROL	I	DF, GF	.000	.000	.000	.000	.000	.000	.000	.000	
	II	GF, DF	.000	.000	.000	.000	.000	.000	.000	.000	
	III	GF, DF	.000	.000	.000	.000	.000	.000	.000	.000	
	IV	GF, DF	.000	.000	.000	.000	.000	.000	.000	.000	
LIFE STAGE MORTALITY	I	DF, GF							.500	.500	
	II	DF, GF							.620	.600	
	III	DF, GF							.750	.850	
	IV	DF, GF							.800	.900	
NOMINAL EGG MASS SIZE	I	DF, GF									200.0
	II	DF, GF									200.0
	III	DF, GF									150.0
	IV	DF, GF									150.0
DESTRUCTION/CONSUMPTION RATIOS											
NEW FOLIAGE	I, II, III	DF, GF	5.400	6.250	6.250	2.710	2.270	2.200			
OLD FOLIAGE	I, II, III	DF, GF	5.400	6.250	6.250	3.690	3.290	3.200			
MEAN INDIVIDUAL LARVAL GROWTH RATE	I, II, III	DF, GF	1147	.1147	1147	.0886	.0625	0625			

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PHASE SPECIFIC MEAN EGG DENSITY BY PHASE: I= .000 II= .000 III= .000 IV= .000

Table 4. First output table from simulation with control.

		PHASE I						PHASE II					
		INPUTS			OUTPUTS			INPUTS			OUTPUTS		
TREE CLASS NO.	NUMBER OF STEMS	VIABLE EGGS (NO.)	TOTAL FOLIAGE BIOMASS (GRAMS)	PERCENT NEW FOLIAGE (%)	DEFOLIATION (%)	VIABLE EGGS LAID (NO.)	REDISTRIBUTED EGGS (NO.)	VIABLE EGGS (NO.)	TOTAL FOLIAGE BIOMASS (GRAMS)	PERCENT NEW FOLIAGE (%)	DEFOLIATION (%)	VIABLE EGGS LAID (NO.)	REDISTRIBUTED EGGS (NO.)
1	.000	.000	.000	.000	.000	.000	.000	50.000	230.000	30.000	2.294	43.064	43.064
2	.000	.000	.000	.000	.000	.000	.000	75.000	230.000	30.000	3.441	64.595	64.595
3	.000	.000	.000	.000	.000	.000	.000	110.000	230.000	30.000	5.046	94.740	94.740
4	.000	.000	.000	.000	.000	.000	.000	150.000	230.000	30.000	6.882	129.191	129.191
5	.000	.000	.000	.000	.000	.000	.000	200.000	230.000	30.000	9.175	172.254	172.254
		PHASE III						PHASE IV					
1	.000	17.225	229.209	29.758	6.434	18.786	18.786	2.818	227.780	29.318	1.404	.505	.505
2	.000	25.838	228.813	29.637	9.651	28.179	28.179	4.227	226.671	28.972	2.106	.757	.757
3	.000	37.896	228.259	29.466	14.154	41.329	41.329	6.199	225.117	28.482	3.089	1.111	1.111
4	.000	51.676	227.626	29.270	19.301	56.357	56.357	8.454	223.341	27.913	4.212	1.515	1.515
5	.000	68.902	226.835	29.023	25.735	75.143	75.143	11.271	221.121	27.189	5.617	2.020	2.020

Table 5. Second output table from simulation with control.

TREE CLASS NO	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS PHASE I	MODEL BRANCH: PERCENT DEFOLIATION BY PHASE				PERCENT OF TREE TOTALLY DEFOLIATED	PER CENT OF TREES RECEIVING:			
				I	II	III	IV		DIRECT MORTALITY	SECONDARY MORTALITY	TOP KILL	ONLY GROWTH REDUCTION
1	.0	.0	.000	.000	2.294	6.434	1.404	.000	.0	4.4	5.6	90.0
2	.0	.0	.000	.000	3.441	9.651	2.106	.000	.0	4.4	5.6	90.0
3	.0	.0	.000	.000	5.046	14.154	3.089	.000	.0	4.4	5.6	90.0
4	.0	.0	.000	.000	6.882	19.301	4.212	.000	.0	4.4	5.6	90.0
5	.0	.0	.000	.000	9.175	25.735	5.617	.001	.0	4.4	5.6	90.0

TREE CLASS NO.	NUMBER OF TREES	WEIGHT FACTOR PER TREE	INITIAL VIABLE EGGS PHASE I	PER CENT OF TREES BY PERCENT REDUCTION IN CROWN HEIGHT					GROWTH IN SURVIVING TREES WITH NO TOP KILL PERCENT OF NOMINAL		DIAMETER GROWTH IN TREES WITH TOP KILL
				0.0	5.0	17.5	37.5	70.0	DIAMETER	HEIGHT	PERCENT OF NOMINAL
1	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
2	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
3	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
4	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00
5	.0	.0	.00	3.4	1.2	.4	.4	.2	85.00	85.00	85.00

Table 6. Third output table from simulation with control.

DESCRIPTION	PHASE	SPECIES	INSTAR 1	2	3	4	5	6	OCCASION PUPAE/ADULT	OVERWINTER	EGG MASS SIZE
DAILY MORTALITY SOURCE			DAILY MORTALITY RATE						LIFE STAGE MORTALITY RATES		
BACKGROUND	I, II, III, IV	DF, GF	.020	.020	.020	.020	.020	.020			
DISEASE	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.002	.003	.006	.013	.035	.028			
	IV	DF, GF	.025	.028	.031	.034	.035	.035			
PARASITE/PREDATOR	I	DF, GF	.000	.000	.000	.000	.000	.000			
	II	DF, GF	.000	.000	.000	.000	.001	.001			
	III	DF, GF	.001	.002	.003	.010	.016	.042			
	IV	DF, GF	.005	.006	.007	.021	.033	.056			
STRESS	I, II, III, IV	DF	.920	.600	.070	.000	.000	.000			
	I, II, III, IV	GF	.950	.700	.100	.020	.000	.000			
CONTROL	I	DF, GF	.000	.000	.000	.000	.000	.000	.000	.000	
	II	GF, DF	.224	.000	.000	.000	.000	.000	.000	.000	
	III	GF, DF	.000	.000	.000	.000	.000	.000	.000	.000	
	IV	GF, DF	.000	.000	.000	.000	.000	.000	.000	.000	
LIFE STAGE MORTALITY	I	DF, GF							.500	.500	
	II	DF, GF							.620	.600	
	III	DF, GF							.750	.850	
	IV	DF, GF							.800	.900	
NOMINAL EGG MASS SIZE	I	DF, GF									200.0
	II	DF, GF									200.0
	III	DF, GF									150.0
	IV	DF, GF									150.0
DESTRUCTION/CONSUMPTION RATIOS											
NEW FOLIAGE	I, II, III	DF, GF	5.400	6.250	6.250	2.710	2.270	2.200			
OLD FOLIAGE	I, II, III	DF, GF	5.400	6.250	6.250	3.690	3.290	3.200			
MEAN INDIVIDUAL LARVAL GROWTH RATE	I, II, III	DF, GF	1147	1147	.1147	.0886	.0625	.0625			

REDISTRIBUTION COEFFICIENT FOR THE OUTBREAK .000

PHASE SPECIFIC MEAN EGG DENSITY BY PHASE. I= 000 II= .000 III= 000 IV= .000

Table 7. Detailed information from simulation with control.

	NUMBER OF INSECTS INITIATION OF YEAR				NUMBER OF INSECTS START FIRST INSTAR				NUMBER OF INSECTS START SECOND INSTAR			
	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS
TREE CLASS	I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	.000	50.000	17.225	2.818	.000	50.000	17.225	2.818	.000	3.239	13.658	1.700
2.	.000	75.000	25.838	4.227	.000	75.000	25.838	4.227	.000	4.858	20.487	2.550
3.	.000	110.000	37.896	6.199	.000	110.000	37.896	6.199	.000	7.126	30.048	3.740
4	.000	150.000	51.676	8.454	.000	150.000	51.676	8.454	.000	9.717	40.974	5.100
5.	.000	200.000	68.902	11.271	.000	200.000	68.902	11.271	.000	12.956	54.632	6.800

	NUMBER OF INSECTS START THIRD INSTAR				NUMBER OF INSECTS START FOURTH INSTAR				NUMBER OF INSECTS START FIFTH INSTAR			
	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS
TREE CLASS	I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	.000	2.646	10.615	.985	.000	2.162	7.925	.547	.000	1.767	5.138	.256
2.	.000	3.970	15.922	1.477	.000	3.244	11.887	.821	.000	2.650	7.707	.384
3.	.000	5.822	23.352	2.166	.000	4.757	17.434	1.204	.000	3.887	11.303	.563
4.	.000	7.939	31.844	2.954	.000	6.487	23.774	1.642	.000	5.300	15.413	.768
5.	.000	10.586	42.459	3.938	.000	8.649	31.699	2.189	.000	7.067	20.551	1.024

	NUMBER OF INSECTS START SIXTH INSTAR				NUMBER OF INSECTS END LARVAL STAGE-START PUPAL				NUMBER OF INSECTS ADULT FEMALES TO PRODUCE EGGS			
	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS	SPECIES GRAND	%NEW FOLIAGE 30.00	TOTAL FOL. 230.000	BIOMASS
TREE CLASS	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	.000	.708	1.251	.052	.000	.567	.501	.017	.000	.215	.125	.003
2	.000	1.061	1.876	.079	.000	.850	.751	.025	.000	.323	.188	.005
3	.000	1.557	2.752	.115	.000	1.247	1.102	.037	.000	.474	.276	.007
4	.000	2.123	3.753	.157	.000	1.700	1.503	.050	.000	.646	.376	.010
5	.000	2.830	5.004	.209	.000	2.267	2.004	.067	.000	.861	.501	.013

Table 7. (Continued)

NUMBER OF INSECTS
BEFORE OVERWINTER MORTALITY

SPECIES	%NEW FOLIAGE	TOTAL FOL.	BIOMASS
GRAND	30.00	230.000	

TREE CLASS	I	II	III	IV
1.	.000	43.064	18.786	.505
2.	.000	64.595	28.179	.757
3.	.000	94.740	41.329	1.111
4.	.000	129.191	56.357	1.515
5	.000	172.254	75.143	2.020